PATENT ABSTRACTS OF JAPAN

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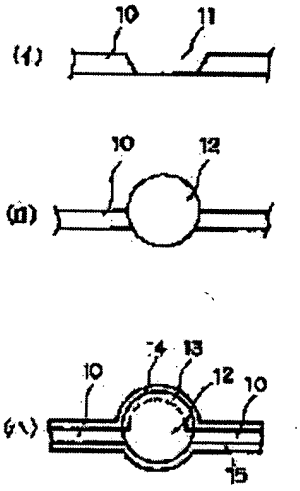
(54) PHOTOVOLTAIC DEVICE

(57)Abstract:
PURPOSE: To provide a photovoltaic device which is easy to manufacture and is excellent in efficiency.
CONSTITUTION: A photovoltaic device comprises an insulating thin film 10, a spherical p-type semiconductor material 12, which is so set as to pierce the insulating thin film 10, an n-type diffused layer 13, which is provided by diffusing n-type semiconductor impurities in the surface of the semiconductor material 12 on one main surface side of the insulating thin film, a translucent electrode 14, which is made to cover each surface of the insulating film 10 and the semiconductor material 12 on the main surface side, and an electrode 15, which is made on the other main surface of the insulating thin film 10.



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CLAIMS

[Claim(s)]
[Claim 1] An insulating thin film and the spherical 1 conductivity-type semiconductor material by which fitting was carried out so that said insulating thin film might be penetrated, The semi-conductor junction established by making the front face of said semiconductor material by the side of the 1 principal plane of said insulating thin film diffuse another conductivity-types semi-conductor impurity, the electrode of the translucency formed so that each front face of said insulating thin film by the side of said principal plane and said semiconductor material might be covered, and other electrodes formed in the other principal planes of said insulating thin film -- since -- the photoelectromotive-force equipment characterized by becoming.
[Claim 2] The semiconductor material possessing the semi-conductor junction formed along the front face which penetrates the electrode which consists of a metal membrane, and this electrode, and is in the 1 principal-plane side of an electrode at a contact section list with said electrode, In photoelectromotive-force equipment equipped with the insulator layer which covers the other principal planes of said electrode, and the periphery of said semiconductor material exposed to the principal plane side in addition to this Photoelectromotive-force equipment which is said other principal plane side of said semiconductor material, and is characterized by making an electrode form in opening by drilling of the part which is not covered with said insulator layer.
[Claim 3] Photoelectromotive-force equipment characterized by making semi-conductor junction provide in each arrangement section by arranging at least one or more other conductivity-types semiconductor materials on the front face of a spherical 1 conductivity-type semiconductor material.
[Claim 4] The 1 conductivity-type semiconductor material which has the configuration of a multiple drill, and the electrode which consists of a metal put on the base of this semiconductor material, The semi-conductor junction which has a plane of composition parallel to this principal plane by diffusing another conductivity-types decision impurity in at least one principal plane other than said base, the metal membrane which is attached so that it may penetrate by the top-most vertices which are on a vertical line to said base among the top-most vertices of said multiple drill, and makes said principal plane and electrical installation -- since -- the photoelectromotive-force equipment characterized by having the becoming electrode.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to photoelectromotive-force equipment.
[0002]
[Description of the Prior Art] The photoelectromotive-force equipment which makes the semi-conductor layer of a non-quality silicon system equipped with semi-conductor junction an optical barrier layer is known. That basic configuration is carrying out the laminating of the transparence electric conduction film, a semi-conductor light barrier layer, and the back plate layer to this sequence on the substrate of translucency.
[0003] The photoelectromotive-force equipment of a different type from the above-mentioned laminating mold photoelectromotive force is proposed by U.S. Pat. No. 4,917,752. This photoelectromotive-force equipment diffuses n mold impurity on the front face of a p type silicon grain with a diameter of 1mm or less, and forms p/n junction in it. It embeds at the pore which prepared the silicon grain in which this p/n junction was formed in the aluminum thin film used as one electrode, and it is constituted so that the field which removed a part of n mold impurity may be joined to the electrode of another side.
[0004]
[Problem(s) to be Solved by the Invention] This invention makes it that technical problem for manufacture to offer easy and efficient photoelectromotive-force equipment in the photoelectromotive-force equipment of a different type from the photoelectromotive-force equipment of the laminating mold mentioned above.
[0005]
[Means for Solving the Problem] The photoelectromotive-force equipment concerning invention of the 1st of this invention An insulating thin film and the spherical 1 conductivity-type semiconductor material by which fitting was carried out so that said insulating thin film might be penetrated, The semi-conductor junction established by making the front face of said semiconductor material by the side of the 1 principal plane of said insulating thin film diffuse another conductivity-types semi-conductor impurity, the electrode of the translucency formed so that each front face of said insulating thin film by the side of said principal plane and said semiconductor material might be covered, and other electrodes formed in the other principal planes of said insulating thin film -- since -- it is characterized by becoming.
[0006] The photoelectromotive-force equipment concerning invention of the 2nd of this invention The semiconductor material possessing the semi-conductor junction formed along the front face which penetrates the electrode which consists of a metal membrane, and this electrode, and is in the 1 principal-plane side of this electrode at a contact section list with said electrode, In photoelectromotive-force equipment equipped with the insulator layer which covers the periphery of said semiconductor material exposed to this other principal plane [of said electrode], and other principal plane side, it is said other principal plane side of said semiconductor material, and is characterized by making an electrode form in opening by drilling of the part which is not covered with said insulator layer.
[0007] The photoelectromotive-force equipment concerning invention of the 3rd of this invention is characterized by making semi-conductor junction provide in each arrangement section by arranging at least one or more other conductivity-types semiconductor materials on the front face of a spherical 1 conductivity-type semiconductor material.
[0008] The photoelectromotive-force equipment concerning invention of the 4th of this invention The 1 conductivity-type semiconductor material which has the configuration of a multiple drill, and the electrode which consists of a metal put on the base of this semiconductor material, The semi-conductor junction which has a plane of composition parallel to this principal plane by diffusing another conductivity-types decision impurity in at least one principal plane other than said base, It is characterized by having the

electrode which consists of a metal membrane which is attached so that it may penetrate by the top-most vertices which are on a vertical line to said base among the top-most vertices of said multiple drill, and makes said principal plane and electrical installation.
[0009]
[Function] According to the photoelectromotive-force equipment of the 1st invention, while being able to form p/n junction at low temperature, the electrode of translucency can be used as an antireflection film.
[0010] According to the 2nd invention, by preparing an electrode in opening by drilling, collection of a carrier is promoted and conversion efficiency improves.
[0011] According to the 3rd invention, p/n junction can be formed very easily only by preparing two kinds of silicon grains.
[0012] According to the 4th invention, since incidence of all the light is carried out from across, conversion efficiency improves according to the so-called texture effectiveness.
[0013]
[Example] Hereafter, with reference to a drawing, it explains per example of this invention.
[0014] First, the example of the 1st invention is explained according to process drawing of drawing 1 .
[0015] As shown in drawing 1 (b), the hole 11 with a diameter [equivalent to the diameter of a silicon grain] of 400 micrometers is established in the insulating thin film substrate 10 of 100 micrometers of thickness, such as a polyimide film.
[0016] Then, as shown in drawing 1 (b), grain-like p mold single crystal silicon 12 is inserted in the hole 11. And n type layer 13 is formed in a principal plane side, and p/n junction is formed.
[0017] For example, by the plasma-CVD method, formation of this n type layer can dope PH3 1%, and can form it by forming n mold amorphous silicon of 60A of thickness, and performing 13.56MH2 plasma excitation in PH3 (1%) / H2 mixed gas for 10 minutes. In addition, the substrate temperature at this time is 250 degrees C, and power density is 30 mW/cm2 and pressure 0.1Torr.
[0018] Then, as shown in drawing 1 (Ha), the photoelectromotive-force equipment applied to the 1st invention by the spatter at a principal plane side by forming the metal electrode 15 of 5000A of thickness which consists of aluminum (aluminum) the transparent electrode 14 which consists of ITO of 800A of thickness with vacuum deposition at a rear-face side is obtained.
[0019] Thus, since according to the photoelectromotive-force equipment of this 1st invention ITO has an acid-resisting function while being able to form p/n junction in a low-temperature process, it is not necessary to form an antireflection film separately.
[0020] Next, the example of the 2nd invention is explained according to process drawing of drawing 2 . As shown in drawing 2 (b), the hole 21 with a diameter [equivalent to the diameter of a silicon grain] of 400 micrometers is established in the metal membrane 20 of about 1/20mm of thickness which consists of aluminium foil.
[0021] Next, as shown in drawing 2 (b), the silicon grain 22 which formed n type layer 22b in the front face with the grain-like silicon grain 22 with which p/n junction was formed, i.e., p type silicon single crystal grain 22a etc., is inserted in a hole 21.
[0022] Then, as shown in drawing 2 (Ha), dry etching removes selectively the other principal planes of a metal membrane 20, i.e., n type layer 22b exposed caudad.
[0023] Then, as shown in drawing 2 (d), the insulator layer 23 of 1000A of thickness which consists of SiO2 is formed with an ordinary pressure CVD method etc. all over metal membrane 20 underside including the silicon grain 22.
[0024] The insulator layer 23 of the other principal planes of the silicon grain 22 is removed mechanically, and maximum phi100micrometer p type layer 22 is made to expose, as shown in drawing 2 (e) the appropriate back.
[0025] Next, as shown in drawing 2 (**), output 1000 mJ/cm2 and beam diameter phi50-micrometer excimer laser are irradiated, and the hole 24 attained to a grained center position is formed in the exposed surface of this p type layer 22.
[0026] and -- drawing 2 -- (**) -- being shown -- as -- this -- a hole -- 24 -- a metal -- a parent -- p type silicon -- a grain -- it is -- a case -- silicon -- receiving -- p -- a mold -- becoming -- aluminum -- (-- aluminum --) -- 25 -- vacuum evaporationo -- enclosing -- after that -- a rear face -- the whole -- aluminum -- (-- aluminum --) -- a thin film -- 26 -- fixing -- the -- two -- invention -- starting -- photoelectromotive force -- obtaining -- having .
[0027] Thus, according to this 2nd invention, collection of the carrier within a grain is promoted by the enclosed aluminum 25, and conversion efficiency improves.
[0028] Next, according to drawing 3 , it explains about the example of the 3rd invention. The silicon grain 32 which consists of two kinds of globular form silicon grains 31, for example, the silicon grain which consists of p layers of high resistance, and n layers of low resistance is formed, these are joined and

semi-conductor pn junction is formed.
[0029] The magnitude of two kinds of globular form silicon grains 31 and 32 makes particle size of the silicon grain 32 of low resistance smaller than the particle size of the silicon grain 31 of high resistance. The ratio of two kinds of this particle size is 1/10 or less.
[0030] After carrying out junction formation with two kinds of silicon grains 31 and 32, this is carried on the metallic foil 33 in which the thin oxide film 34 was formed, from a rear face, carry out a heat exposure, the metal of a metallic foil 33 is made to permeate the silicon grain 31, and one electrode is formed in the shape of a spot.
[0031] Electrode formation to the globular form silicon grain 32 with a small particle size with another conductivity type forms a thin oxide film in the side to which the globular form silicon grain 31 with a small particle size is attached first, forms the transparence electric conduction film 35 on this, and forms an electrode by heat annealing.
[0032] The photoelectromotive-force equipment concerning the 3rd invention is obtained by furthermore forming a surface protective coat, an oxide film, or the protection resin film.
[0033] Next, lessons is taken from the example of this 3rd invention, and it explains further. First, silicon is ground and a desired silicon grain is formed.
[0034] 1300 degrees C - 1400 degrees C heat treatment is performed in H2 ambient atmosphere, and a form is prepared. The produced bulk resistivity 0.1 - 1.0 ohm-cm, and the p type silicon grain 31 with a particle size of about 1mm are arranged in the shape of 1 particle layer on a ceramic tray.
[0035] besides -- the bulk resistivity of 0.01-0.006ohms and cm, and n mold silicon grain 32 with a particle size of about 10 micrometers -- several grain child -- it arranges in layers.
[0036] Where the two-layer structural sequence of a large drop child and the granule child is carried out, this is performed, zone annealing is performed at 1300-1400 degrees C, and adhesion and junction formation of two kinds of silicon grains are performed. The above-mentioned particle by which junction formation was carried out is arranged on the sheet which consists of two-layer [of a 100-200A thickness oxide thin film and a metallic foil], and is stuck by pressure lightly.
[0037] Laser radiation is carried out to jointing of a particle and a metal thin film, and a particle part is made to carry out melting osmosis of the metal from a rear-face side.
[0038] a front-face side -- thin -- a 50-100A thickness oxide film is formed, and laminating formation of the transparent conductive thin film (ITO) is carried out further.
[0039] The property of the solar battery produced by the producing method shown above is shown in a table 1.
[0040]
[A table 1]

	諸特性
Voc	0.56V
Isc	25mA/cm²
F.F	0.65
Power	9.1mW/cm²

AM1.5 100 mW/cm2 exposure [0041] Next, with reference to drawing 4 thru/or drawing 6 , it explains about the example of the 4th invention. In this 4th invention, as shown in drawing 4 , the silicon component which consists of a regular tetrahedron or a triangular pyramid is used. The silicon component of this regular tetrahedron is formed as follows [a base] at about 0.1-10mm.
[0042] For example, there are an approach of fusing silicon with a mold and making it solidify, the approach of forming the end of a silicon grain by anisotropic etching at the temperature of 85 degrees C the magnitude of about 0.1-10mm of the configuration of this arbitration with NaOH, KOH, etc., etc.
[0043] Furthermore, if the liquid phase epitaxy using Sn melt is performed using the bad substrate of leakage nature like an alumina, the silicon of many tetrahedrons can also be formed in the shape of a substrate.

[0044] As shown in drawing 5 , n type layer 41 which consists of a regular tetrahedron formed by doing in this way and which n mold impurity diffused in principal planes other than the base of the p type silicon block 42 is formed, and the p/n junction which has a plane of composition parallel to this principal plane is formed, for example. And to the base of the silicon block 40, it penetrates from top-most vertices, a metal membrane 42 is formed on a vertical line, and n type layer 41, the metal membrane 42, and electrical installation of the silicon block 40 are taken.
[0045] Moreover, a metal electrode 44 is formed in the base of the silicon block 40 through an insulating layer 42, and the electrical installation of the p layers and metal electrode 44 of the silicon block 40 is taken.
[0046] Thus, since incidence of the light is altogether carried out from across by forming as shown in drawing 5 , conversion efficiency improves according to the so-called texture effectiveness.
[0046] In addition, although the above-mentioned example explained the silicon block of a drawing object, as shown in drawing 6 , it can also consist of silicon blocks of the triangle pole.
[0047]
[Effect of the Invention] As explained above, while being able to form p/n junction at low temperature according to the photoelectromotive-force equipment of the 1st invention, the electrode of translucency can be used as an antireflection film and structure can offer the easy and, easy photoelectromotive-force equipment of manufacture.
[0048] Moreover, according to the 2nd invention, by preparing an electrode in opening by drilling, collection of a carrier is promoted and conversion efficiency improves.
[0049] Furthermore, according to the 3rd invention, p/n junction can be formed very easily only by preparing two kinds of silicon grains.
[0050] According to the 4th invention, since incidence of all the light is carried out from across, conversion efficiency improves according to the so-called texture effectiveness.

[Translation done.]

TECHNICAL FIELD

[Industrial Application] This invention relates to photoelectromotive-force equipment.

[Translation done.]

PRIOR ART

[Description of the Prior Art] The photoelectromotive-force equipment which makes the semi-conductor layer of a non-quality silicon system equipped with semi-conductor junction an optical barrier layer is known. That basic configuration is carrying out the laminating of the transparence electric conduction film, a semi-conductor light barrier layer, and the back plate layer to this sequence on the substrate of translucency.
[0003] The photoelectromotive-force equipment of a different type from the above-mentioned laminating mold photoelectromotive force is proposed by U.S. Pat. No. 4,917,752. This photoelectromotive-force equipment diffuses n mold impurity on the front face of a p type silicon grain with a diameter of 1mm or less, and forms p/n junction in it. It embeds at the pore which prepared the silicon grain in which this p/n junction was formed in the aluminum thin film used as one electrode, and it is constituted so that the field which removed a part of n mold impurity may be joined to the electrode of another side.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] As explained above, while being able to form p/n junction at low temperature according to the photoelectromotive-force equipment of the 1st invention, the electrode of translucency can be used as an antireflection film and structure can offer the easy and, easy photoelectromotive-force equipment of manufacture.
[0048] Moreover, according to the 2nd invention, by preparing an electrode in opening by drilling, collection of a carrier is promoted and conversion efficiency improves.
[0049] Furthermore, according to the 3rd invention, p/n junction can be formed very easily only by preparing two kinds of silicon grains.
[0050] According to the 4th invention, since incidence of all the light is carried out from across, conversion efficiency improves according to the so-called texture effectiveness.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] This invention makes it that technical problem for manufacture to offer easy and efficient photoelectromotive-force equipment in the photoelectromotive-force equipment of a different type from the photoelectromotive-force equipment of the laminating mold mentioned above.

[Translation done.]

MEANS

[Means for Solving the Problem] The photoelectromotive-force equipment concerning invention of the 1st of this invention An insulating thin film and the spherical 1 conductivity-type semiconductor material by which fitting was carried out so that said insulating thin film might be penetrated, The semi-conductor junction established by making the front face of said semiconductor material by the side of the 1 principal plane of said insulating thin film diffuse another conductivity-types semi-conductor impurity, the electrode of the translucency formed so that each front face of said insulating thin film by the side of said principal plane and said semiconductor material might be covered, and other electrodes formed in the other principal planes of said insulating thin film -- since -- it is characterized by becoming.
[0006] The photoelectromotive-force equipment concerning invention of the 2nd of this invention The semiconductor material possessing the semi-conductor junction formed along the front face which penetrates the electrode which consists of a metal membrane, and this electrode, and is in the 1 principal-plane side of this electrode at a contact section list with said electrode, In photoelectromotive-force equipment equipped with the insulator layer which covers the periphery of said semiconductor material exposed to this other principal plane [of said electrode], and other principal plane side, it is said other principal plane side of said semiconductor material, and is characterized by making an electrode form in opening by drilling of the part which is not covered with said insulator layer.
[0007] The photoelectromotive-force equipment concerning invention of the 3rd of this invention is characterized by making semi-conductor junction provide in each arrangement section by arranging at least one or more other conductivity-types semiconductor materials on the front face of a spherical 1 conductivity-type semiconductor material.
[0008] The photoelectromotive-force equipment concerning invention of the 4th of this invention The 1 conductivity-type semiconductor material which has the configuration of a multiple drill, and the electrode which consists of a metal put on the base of this semiconductor material, The semi-conductor junction which has a plane of composition parallel to this principal plane by diffusing another conductivity-types decision impurity in at least one principal plane other than said base, It is characterized by having the electrode which consists of a metal membrane which is attached so that it may penetrate by the top-most vertices which are on a vertical line to said base among the top-most vertices of said multiple drill, and makes said principal plane and electrical installation.

[Translation done.]

OPERATION

[Function] According to the photoelectromotive-force equipment of the 1st invention, while being able to form p/n junction at low temperature, the electrode of translucency can be used as an antireflection film.
[0010] According to the 2nd invention, by preparing an electrode in opening by drilling, collection of a carrier is promoted and conversion efficiency improves.
[0011] According to the 3rd invention, p/n junction can be formed very easily only by preparing two kinds of silicon grains.
[0012] According to the 4th invention, since incidence of all the light is carried out from across, conversion efficiency improves according to the so-called texture effectiveness.
[0013]

[Translation done.]

EXAMPLE

[Example] Hereafter, with reference to a drawing, it explains per example of this invention.
[0014] First, the example of the 1st invention is explained according to process drawing of drawing 1 .
[0015] As shown in drawing 1 (b), the hole 11 with a diameter [equivalent to the diameter of a silicon grain] of 400 micrometers is established in the insulating thin film substrate 10 of 100 micrometers of thickness, such as a polyimide film.
[0016] Then, as shown in drawing 1 (b), grain-like p mold single crystal silicon 12 is inserted in the hole 11. And n type layer 13 is formed in a principal plane side, and p/n junction is formed.
[0017] For example, by the plasma-CVD method, formation of this n type layer can dope PH3 1%, and can form it by forming n mold amorphous silicon of 60A of thickness, and performing 13.56MH2 plasma excitation in PH3 (1%) / H2 mixed gas for 10 minutes. In addition, the substrate temperature at this time is 250 degrees C, and power density is 30 mW/cm2 and pressure 0.1Torr.
[0018] Then, as shown in drawing 1 (Ha), the photoelectromotive-force equipment applied to the 1st invention by the spatter at a principal plane side by forming the metal electrode 15 of 5000A of thickness which consists of aluminum (aluminum) the transparent electrode 14 which consists of ITO of 800A of thickness with vacuum deposition at a rear-face side is obtained.
[0019] Thus, since according to the photoelectromotive-force equipment of this 1st invention ITO has an acid-resisting function while being able to form p/n junction in a low-temperature process, it is not necessary to form an antireflection film separately.
[0020] Next, the example of the 2nd invention is explained according to process drawing of drawing 2 . As shown in drawing 2 (b), the hole 21 with a diameter [equivalent to the diameter of a silicon grain] of 400 micrometers is established in the metal membrane 20 of about 1/20mm of thickness which consists of aluminium foil.
[0021] Next, as shown in drawing 2 (b), the silicon grain 22 which formed n type layer 22b in the front face with the grain-like silicon grain 22 with which p/n junction was formed, i.e., p type silicon single crystal grain 22a etc., is inserted in a hole 21.
[0022] Then, as shown in drawing 2 (Ha), dry etching removes selectively the other principal planes of a metal membrane 20, i.e., n type layer 22b exposed caudad.
[0023] Then, as shown in drawing 2 (d), the insulator layer 23 of 1000A of thickness which consists of SiO2 is formed with an ordinary pressure CVD method etc. all over metal membrane 20 underside including the silicon grain 22.
[0024] The insulator layer 23 of the other principal planes of the silicon grain 22 is removed mechanically, and maximum phi100micrometer p type layer 22 is made to expose, as shown in drawing 2 (e) the appropriate back.
[0025] Next, as shown in drawing 2 (**), output 1000 mJ/cm2 and beam diameter phi50-micrometer excimer laser are irradiated, and the hole 24 attained to a grained center position is formed in the exposed surface of this p type layer 22.
[0026] and -- drawing 2 -- (**) -- being shown -- as -- this -- a hole -- 24 -- a metal -- a parent -- p type silicon -- a grain -- it is -- a case -- silicon -- receiving -- p -- a mold -- becoming -- aluminum -- (-- aluminum --) -- 25 -- vacuum evaporationo -- enclosing -- after that -- a rear face -- the whole -- aluminum -- (-- aluminum --) -- a thin film -- 26 -- fixing -- the -- two -- invention -- starting -- photoelectromotive force -- obtaining -- having .
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[0030] After carrying out junction formation with two kinds of silicon grains 31 and 32, this is carried on the metallic foil 33 in which the thin oxide film 34 was formed, from a rear face, carry out a heat exposure, the metal of a metallic foil 33 is made to permeate the silicon grain 31, and one electrode is formed in the shape of a spot.
[0031] Electrode formation to the globular form silicon grain 32 with a small particle size with another conductivity type forms a thin oxide film in the side to which the globular form silicon grain 31 with a small particle size is attached first, forms the transparence electric conduction film 35 on this, and forms an electrode by heat annealing.
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[0034] 1300 degrees C - 1400 degrees C heat treatment is performed in H2 ambient atmosphere, and a form is prepared. The produced bulk resistivity 0.1 - 1.0 ohm-cm, and the p type silicon grain 31 with a particle size of about 1mm are arranged in the shape of 1 particle layer on a ceramic tray.
[0035] besides -- the bulk resistivity of 0.01-0.006ohms and cm, and n mold silicon grain 32 with a particle size of about 10 micrometers -- several grain child -- it arranges in layers.
[0036] Where the two-layer structural sequence of a large drop child and the granule child is carried out, this is performed, zone annealing is performed at 1300-1400 degrees C, and adhesion and junction formation of two kinds of silicon grains are performed. The above-mentioned particle by which junction formation was carried out is arranged on the sheet which consists of two-layer [of a 100-200A thickness oxide thin film and a metallic foil], and is stuck by pressure lightly.
[0037] Laser radiation is carried out to jointing of a particle and a metal thin film, and a particle part is made to carry out melting osmosis of the metal from a rear-face side.
[0038] a front-face side -- thin -- a 50-100A thickness oxide film is formed, and laminating formation of the transparent conductive thin film (ITO) is carried out further.
[0039] The property of the solar battery produced by the producing method shown above is shown in a table 1.
[0040]
[A table 1]

	諸特性
Voc	0.56V
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Power	9.1mW/cm²

AM1.5 100 mW/cm2 exposure [0041] Next, with reference to drawing 4 thru/or drawing 6 , it explains about the example of the 4th invention. In this 4th invention, as shown in drawing 4 , the silicon component which consists of a regular tetrahedron or a triangular pyramid is used. The silicon component of this regular tetrahedron is formed as follows [a base] at about 0.1-10mm.
[0042] For example, there are an approach of fusing silicon with a mold and making it solidify, the approach of forming the end of a silicon grain by anisotropic etching at the temperature of 85 degrees C the magnitude of about 0.1-10mm of the configuration of this arbitration with NaOH, KOH, etc., etc.
[0043] Furthermore, if the liquid phase epitaxy using Sn melt is performed using the bad substrate of leakage nature like an alumina, the silicon of many tetrahedrons can also be formed in the shape of a

substrate.
[0044] As shown in drawing 5 , n type layer 41 which consists of a regular tetrahedron formed by doing in this way and which n mold impurity diffused in principal planes other than the base of the p type silicon block 42 is formed, and the p/n junction which has a plane of composition parallel to this principal plane is formed, for example. And to the base of the silicon block 40, it penetrates from top-most vertices, a metal membrane 42 is formed on a vertical line, and n type layer 41, the metal membrane 42, and electrical installation of the silicon block 40 are taken.
[0045] Moreover, a metal electrode 44 is formed in the base of the silicon block 40 through an insulating layer 42, and the electrical installation of the p layers and metal electrode 44 of the silicon block 40 is taken.
[0046] Thus, since incidence of the light is altogether carried out from across by forming as shown in drawing 5 , conversion efficiency improves according to the so-called texture effectiveness.
[0046] In addition, although the above-mentioned example explained the silicon block of a drawing object, as shown in drawing 6 , it can also consist of silicon blocks of the triangle pole.

[Translation done.]

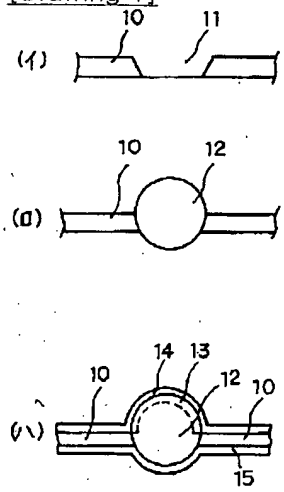
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the sectional view showing the example of the 1st invention according to a process.
[Drawing 2] It is the sectional view showing the example of the 2nd invention according to a process.
[Drawing 3] It is the sectional view showing the example of the 3rd invention.
[Drawing 4] It is the perspective view showing the silicon block used for the 4th invention.
[Drawing 5] It is the sectional view showing the example of the 4th invention.
[Drawing 6] It is the perspective view showing other examples of the 4th invention.
[Description of Notations]
10 Insulating Thin Film Substrate
12 Silicon Grain
14 Transparent Electrode
15 Metal Electrode
20 Metal Membrane
22 Silicon Grain
24 Hole
25 Aluminum
26 Aluminum Thin Film
31 Silicon Grain (P Mold)
32 Silicon Grain (N Mold)
40 Silicon Block

[Translation done.]

DRAWINGS

[Drawing 1]



[Drawing 2]